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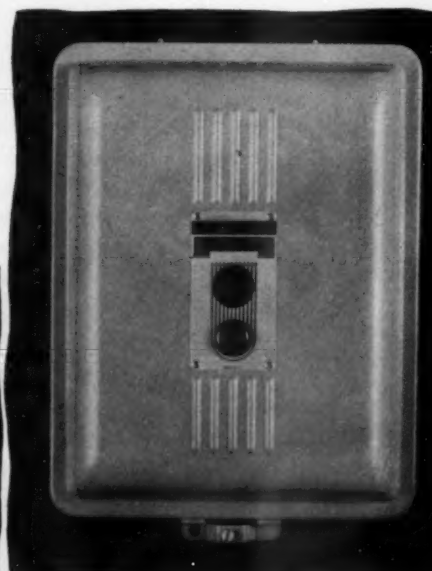
ELECTRIC MOTOR

PROTECTION AND CONTROLS

BY E. S. SHEPARDSON



ELECTRIC MOTOR PROTECTION AND CONTROLS

E. S. SHEPARDSON

Electric motors are among the farmer's best helpers. They are dependable, but will be damaged if they are neglected. They may burn out if not protected by an overload protective device. The ordinary fuse will not protect a motor.

Electricity and Its Heating Effect on Motors

Why an Ordinary Fuse Will Not Protect a Motor

When electricity flows through wires, it produces heat. If the wire is too small for the flow of current, the wire may become hot enough to burn the insulation from it. Electric wiring is protected by the common circuit fuse that contains a fuse link of an alloy that melts at a predetermined temperature. All the current flowing in the circuit must pass through this link. When the current becomes too strong and heats the circuit wiring, the fuse link melts and thus stops the flow of current. A certain size fuse is needed to protect a given size wire.

Simple fuses of this kind cannot protect electric motors against danger from burning out because a simple fuse with a capacity large enough to permit the flow of enough current to start the motor is too large to protect the motor when it is up to running speed.

A motor runs because the electrical pressure (volts) from the supply line causes a current (amperes) to flow through the motor windings, and this current flow sets up magnetic reactions that cause the armature to turn. To get the motor up to speed, a heavy starting current must flow through its windings. If the motor is loaded at starting, this starting current will be especially large. The current to run a motor at full load is much less than that needed for starting. Motors are built to carry continuously this smaller full-load running current without becoming too hot when operated under the conditions for which they are designed.

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In starting, motors normally get up to speed so quickly that the heating effect of the large starting current does not damage them. If the motor does not attain its full speed promptly, the large starting current may have time to cause enough heat to destroy, or to burn out, the motor.

Heat severe enough to damage the motor may also be produced even after the motor has reached full speed. A motor that draws from the line more than its normal full-load (running) current, depending on the amount of the current, may in time become hot enough to burn out. Thus, a small overcurrent for a long period can cause as much dangerous heating as that caused by a large overcurrent for a short period. Motors burn out when the insulation on the windings becomes so hot as to be burned from the wires. This allows the bare wires to contact each other and to cause a short circuit.

Conditions that may bring about dangerous heating at full speed include:

1. Lower than normal voltage on the line supplying power to the motor. Higher-than-normal voltage may do the same, but such voltage seldom occurs.

2. Excessive load on the machine that the motor operates.

3. Friction within the motor itself due to worn bearings.

4. Lack of ventilation of the motor windings due to the location of the motor or to an accumulation of dirt and dust in the air passages. The care of electric motors is discussed in Cornell Extension Bulletin 848.

5. Other bad conditions due to neglect of the motor, such as improper lubrication. Oiling electric motors is discussed in Cornell Extension Bulletin 600.

Conditions that cause delayed starting are the same as those given in paragraphs 1, 2, 3, and 5, above.

Motor Overload Protective Devices

Overheating results from an overcurrent (too much current) or from lack of ventilation about the windings (above). Overloading and low voltage are two common causes of an overcurrent.

The installation of overload protective devices prevents damage from an overcurrent. Only a protective device so installed on the motor as to react from the heat developed within the motor windings will protect a motor against overheating due to lack of ventilation. These overload protective devices differ radically from the common circuit fuse (page 2) because they must meet the following requirements:

1. They must permit the heavy

motor-starting current to flow long enough to start the motor and let it attain full speed.

2. They must break the circuit if the heavy starting current continues to flow so long that the heat generated is dangerous to the motor.

3. They must cut off the running current whenever it becomes even so moderately excessive as to overheat the motor.

4. They must retain their capacity to meet these requirements for an indefinite number of years, even if they have not been called upon to operate during that time and even if they have been long exposed to the corrosive effects of moisture or stable fumes.

Because of these special conditions that motor protective devices must meet, one device can protect only one motor and each device must be of the exact capacity required by that particular motor (tables 1 and 2, pages 6 and 12).

Motor-overload protective devices can be classed generally under two types, the time-delay or delayed-action motor fuse and the thermal overload switch.

The motor and branch circuit must also be protected from a short circuit by the proper branch circuit fuse.

The Delayed-action Fuse

A delayed-action fuse meets all of the requirements listed in the preceding paragraphs. It has been termed a *delayed-action fuse* for lack of a better name. It can be used only once. A blown fuse must always be replaced with a new one, but the fuses are not expensive.

When this type of fuse "blows," something is wrong—it protected the motor from damage by blowing out. The trouble should be found and corrected, and a new delayed-action fuse of the correct size put in the motor circuit. A larger fuse or regular type fuse would only destroy the motor protection.

Delayed-action fuses can be purchased under various trade names.

How the Delayed-action Fuse Protects a Motor

Protection against the excessive heating of too large a running or starting current sustained for a dangerous length of time is through an ingenious device, the delayed-action fuse (figure 1). This fuse includes a fuse link of capacity to permit the flow of the large motor-starting currents without melting but which will melt almost instantly and protect the motor when there is a dangerous short circuit. One end of the fuse link is held in solder in a small cup at the end of the fuse body. A heating coil around the cup carries the en-

tire motor current and produces enough heat to melt the solder if the current flow is enough to injure the motor. When the solder is melted, a spring inside the fuse body pulls the fuse link from the solder cup and thus breaks the circuit and protects the motor.

Size of Fuse

A specific size of delayed-action fuse must be used. The size is determined by the full-load running current (amperes) of the motor, which is always printed on the motor name plate (figure 2), and not by the horsepower of the motor. If the motor can be operated on either 115 or 230 volts, both voltages are given on the name plate. There is also a specific amperage which is the full-load running current for each of the voltages shown on the name plate (figure 2).

The larger amperage is the running current the motor uses when operated on 115 volts and is the one used in determining the size of delayed-action fuse to use when the motor is being operated on 115 volts. The smaller amperage on the motor name plate is the running current the motor draws when being operated on 230 volts, and is the value used in determining the size of the two delayed-action fuses needed to protect the motor when operated on 230 volts.

Ordinarily it is not necessary to use protective devices with rated capacities smaller than 110 per cent, or larger than 125 per cent, of the motor amperage. An exception is the protection for motors of

FIGURE 1. A COMMON CIRCUIT FUSE (A) AND ONE TYPE OF DELAYED-ACTION FUSE (B) FOR MOTOR PROTECTION

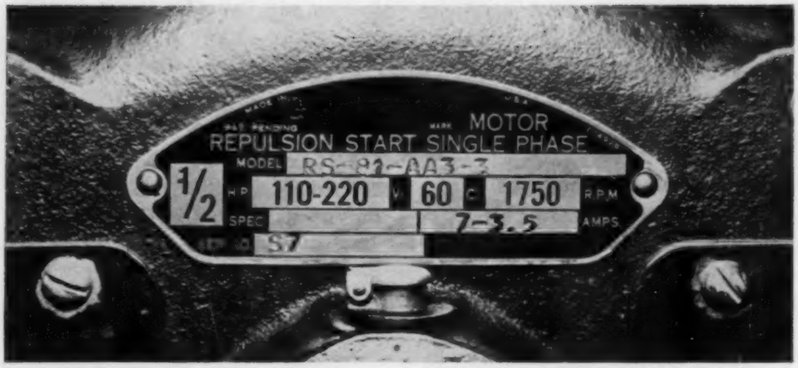

FIGURE 2. A MOTOR NAME PLATE

The plate has all the necessary information about the motor, such as name, type, horsepower, speed, cycles, voltage, amperage, model, and serial number. When operating on 110-volts, this motor draws 7 amperes; on 220-volts, it draws one-half as much, or 3.5 amperes.

less than 5 horsepower that are especially designed for use as part of approved refrigeration equipment. If necessary, they may have a capacity that exceeds 125 per cent of the full-load running current but not more than 140 per cent. For many fractional horsepower motors, a delayed-action fuse of one size larger than the motor name-plate amperage would protect the motor. Table 1 serves as a handy reference to determine the correct size.

Installation

Fuse and switch box

Fuses must always be installed in a covered fuse holder.

On a 115-volt circuit, the delayed-action fuse may not be substituted for the regular fuse in the fuse box to serve as motor protection unless the motor is the only electrical equipment on that particular circuit. If there is other electrical equipment on the circuit, the delayed-action fuse must be installed in that part of the circuit

TABLE 1. SIZE OF DELAYED-ACTION FUSE TO USE*

Motor full load running current (from motor name plate)	Delayed-action fuse size
Amperes	*Amperes*
1.81 to 2.25	2.5
2.26 to 3.0	3.2
3.1 to 3.60	4.0
3.61 to 4.0	4.5
4.1 to 4.55	5.0
4.56 to 5.7	6.25
5.71 to 7.3	8.0
7.31 to 9.25	10.0
9.26 to 11.0	12.0
11.1 to 14.0	15.0
14.1 to 18.0	20.0
18.1 to 22.0	25.0
22.1 to 28.0	30.0

*A motor should not normally require a fuse larger than that shown in this table. If, however, it is necessary to use a fuse one size larger, one should watch the motor carefully for a few days to make certain that it is not overheating. One should be able to hold his hand on it for at least 10 seconds.

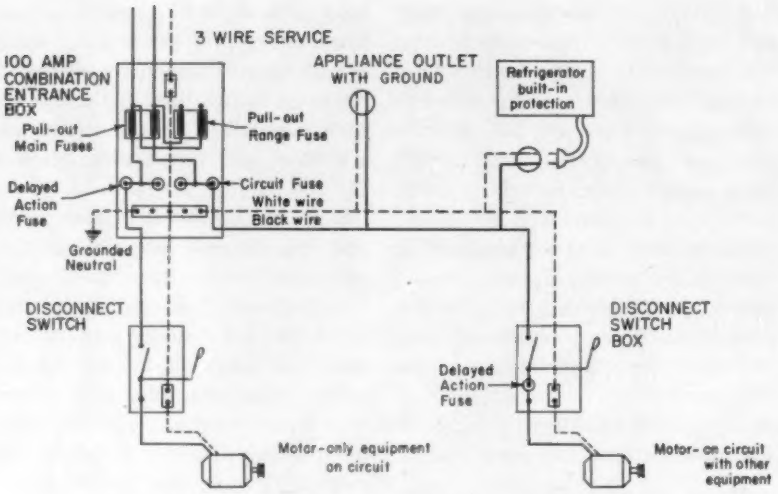

FIGURE 3. DELAYED-ACTION FUSE POSITION IN CIRCUITS WITH MOTORS

The refrigerator motor normally has built-in motor protection. Any motor operated appliance plugged into the appliance outlet would have to have its own protection—for instance the washer. The other motor operated piece of equipment on this circuit has its own disconnecting switch and fuse box with delayed-action fuse for protection.

The circuit fuse can be a delayed-action fuse, 20 amperes for the appliance circuit.

When the motor is the only piece of equipment on the circuit, the delayed-action fuse for motor protection can be combined with the branch circuit protection fuse in the entrance box. There must also be a separate disconnecting means unless the motor is 1/8 horsepower or smaller.

that feeds only the motor (figure 3). The device must carry only the motor current and must be of the correct size or rating for the motor.

However, a 15-ampere delayed-action fuse can be used in place of the ordinary circuit fuse (20 ampere in appliance circuits) to do away with unnecessary blowing of the circuit fuse when the motor starts at the time several appliances are in use. If all electrical outlets are in use, it is possible to determine which outlets are on a particular circuit by removing a fuse.

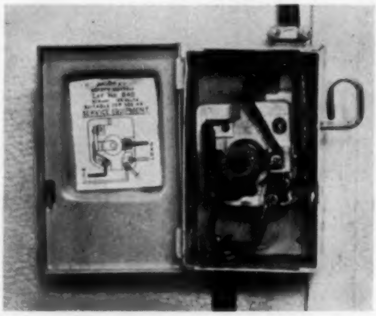

FIGURE 4. A 30-AMPERE SIZE SWITCH AND FUSE BOX FOR A 115-VOLT CIRCUIT, WITH WIRES CONNECTED AND A DELAYED-ACTION FUSE IN PLACE—1 HORSEPOWER

Note the wiring diagram in the switch-box cover, the connectors to hold cable in the box, and the wiring connections

A 30-ampere combination fuse and switch box (figure 4) in the line near the motor is the best method for installing the delayed-action fuse. This size box is suitable for practically all 115-volt farm motors. Boxes especially made for motors are rated in horsepower, although any 30-ampere switch is suitable for motors up to 1 horsepower on 115 volts. It is better practice to operate motors of one-half horsepower and larger on 230-volt current.

The switch box is not difficult to install in a circuit (figures 3 and 4).

Motor circuits that carry 230 volts should have a combination fuse and switch box in the wiring installation and should contain two fuses (figure 5). The delayed-action fuses, either plug or cartridge type, should be substituted for the regular fuses in this box. If there is no such switch box in the wiring installation of a motor already on a 230-volt circuit, one should be installed. For motors of 2 horsepower and less, the switch box, if rated in amperes, should have an ampere rating double that of the motor; if rated in horsepower, its ratings should correspond to that of the motor. For example, any motor with a current rating of 15 amperes or less could use a standard 30-ampere switch box; a 3/4-horsepower motor might use a motor control box designed to handle mo-

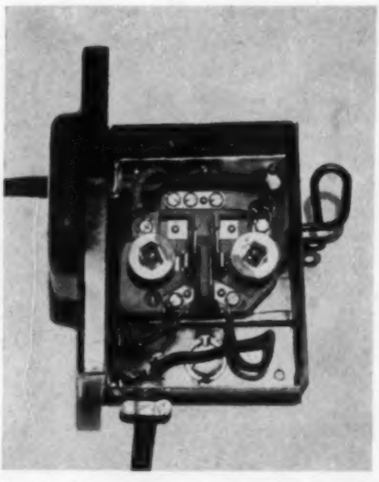

FIGURE 5. A COMBINATION FUSE AND SWITCH BOX FOR A 230-VOLT CIRCUIT, SHOWING WIRING CONNECTIONS AND DELAYED-ACTION FUSES—2 HORSEPOWER

FIGURE 6. FUSE RECEPTACLE IN BOX WITH SWITCH

A tamper-proof receptacle can be installed if desired. Cover is self-closing

tors of 1 horsepower or less, and rated 1 horsepower.

For farm motors of more than 2 horsepower, the fuse and switch box should be one designed for motor control and be rated in horsepower.

These switches are known in the electrical trade as "type C" switches. They have a spring action which gives quick opening and closing of the switch blades. This feature helps to prevent burning or sparking when the switch is operated. Ordinary safety switches known as "type D" lack this quick-acting feature and are not rated in horsepower. "Type A" switches are similar to "type C" but are so made that the switch cover cannot be opened unless the switch is in the off position. "Type A" or "type C" switches are approved for farm motors of 3, 5, or more horsepower.

Other methods

A special receptacle designed for motor protection, mounted on various box covers (figure 6), is a simple and inexpensive means of protecting small motors. The receptacle has a cover that closes over the time delay fuse. The device can be obtained in combination with switch, receptacle, or plain.

This device can be used only for 115-volt operation.

Motor Controls with Thermal Overload Protection

Many types of motor-control switches with thermal overload protection are available. Generally they fall into two classes, the manual and the magnetic types.

Unlike the delayed-action fuse, these may be reset when the motor is ready to run. For fractional horsepower motors, some are "built" into the motor at the factory and may be of the automatic reset or of the manual reset type (figure 7).

NOTE: The round attachment or "can" on top of the motor is not the protector. It is merely the capacitor on a capacitor start motor.

The manual reset type is often incorporated with the equipment which the motor drives, for example those combined with the pressure switch of a water system (figure 8). Usually it can be identified by a button that has *Push to Reset* printed on or near it.

These devices may be obtained as individual installations for those motors that are not already equipped with an overload protective device. They can be mounted either on the equipment or on a surface close by the motor (figure 9). Some may be used also as a motor control switch (figures 9 and 12).

A cord plug with built-in overload protection that can be manually reset after being tripped by

PHOTOGRAPHS FROM WESTINGHOUSE

FIGURE 7. BUILT-IN OVERLOAD PROTECTION
Upper inset, fully automatic; lower inset, manual-reset type

an overload may be used on small appliances (figure 10). This plug must be purchased specifically for the motor it is to protect; that is, it must correspond to the amperage of the motor as shown in table 2. It is suitable for small, portable, motors operating at 115 volts.

A thermal switch built to substitute for a fuse is also made for small motor protection as well as standard circuit sizes (figure 11).

FIGURE 8. OVERLOAD PROTECTION COMBINED WITH THE PRESSURE SWITCH OF A WATER SYSTEM
Note the reset button

FIGURE 9. THERMAL SWITCH FOR FRACTIONAL HORSEPOWER MOTORS
Mounted on the wall nearby, on the motor, or on the equipment.

How Thermally Operated Switches Protect a Motor

Thermally operated switches differ from the delayed-action fuse in that they contain a bimetallic strip surrounded by, or near, a heating coil, called the *heater*. The two metals of the bimetallic strip expand unevenly when heated by the heating coil and this causes them to bend. The bimetallic strip bends far enough to cause the switch mechanism to be opened, thus disconnecting the motor from the line.

Some use the melting alloy and ratched reset principle, but their function is the same.

Size of Heater

In general, the size of heater to be used in thermal switches is determined in the same way as for

FIGURE 10. CORD PLUG WITH BUILT-IN THERMAL CUTOUT OVERLOAD PROTECTION
Arrow indicates reset lever

TABLE 2. SIZE OF HEATER TO USE IN THERMAL CUTOUT DEVICES*

Motor full-load running current (from motor name plate)	Maximum setting of time-limit device (size of heater)
Amperes	*Amperes*
3	3.75
4	5.0
5	6.25
6	7.50
7	8.75
8	10.0
9	11.25
10	12.50
11	13.75
12	15.0
13	16.25
14	17.50
15	18.75
16	20.00
17	21.25
18	22.50
19	23.75
20	25.00
22	27.50
24	30.00
26	32.50
28	35.00
30	37.50
32	40.00
34	42.50
36	45.00
38	47.50
40	50.00
42	52.50
44	55.00
46	57.50
48	60.00

*From 1956 National Electrical Code.

delayed-action fuses. Heaters, however, are made in a greater number of sizes, and some may afford protection well within the 110 to 125 per cent limits, which is not always possible with the delayed-action fuse. Some of the more common sizes are listed in table 2. Note that these are the *maximum* sizes allowed.

This type of protection sometimes causes difficulty because of unnecessary tripping where ambient temperatures become unusually high, or fluctuate greatly.

Types of Thermal Controls

Manual or magnetic controls with thermal overload protection are often used for motors of 1 horsepower and up to 7½ horsepower. Fused switches may also be used in many situations.

FIGURE 11. THERMAL SWITCH BUILT TO SUBSTITUTE FOR A FUSE

It may be reset by center push-pin after tripping.

FIGURE 12. ONE TYPE OF MANUAL CONTROL —A TOGGLE-OPERATED 1½ HORSEPOWER THERMAL SWITCH CONTROL

The manual control consists of a hand-operated switch which is used to turn the motor on and off, together with an automatic device operated by a heater which throws the switch off if the motor draws enough current to damage the windings. Manual controls are operated by a lever, toggle, or pair of push-buttons mounted in the cover (figures 9, and 12). When the automatic cutout operates to stop the motor, it is necessary to let the heater cool off and then set the switch in the off position before turning the motor on again.

The magnetic control consists of a switch that is operated by a coil magnet. Current to the magnet is controlled by a small switch which may be mounted in the switch box cover or it may be a separate device (figures 13 and 16).

When the magnet coil is turned on, the magnetic switch is thrown into the "on" position and the motor runs. When the magnet coil is turned off, the switch opens and the motor stops. A heater device, similar to that used on the manual control cuts off the current to the coil and stops the motor to prevent damage from overloading. When this happens, a "Reset" button on the switch box must be pushed before the motor can be started.

The Motor Circuit

Every motor circuit must have:

1. the branch circuit overcurrent protective device,
2. a disconnecting means,
3. the motor control, and
4. motor overcurrent protective device.

The branch circuit protection is usually provided by fuses, although circuit breakers may be used. Its purpose is to protect the branch circuit wiring and, if thermal elements are used for motor protection, to also protect them. Thermal elements are not capable of acting fast enough in the case of a short circuit to protect themselves.

The disconnecting means is for the purpose of completely isolating the motor and its controller (manually operated thermal switch or magnetic switch) from the source of power. This is for servicing of the motor or the controller to prevent electrical hazards to life and property.

The motor controller is simply a device to stop and start the motor conveniently or to facilitate automatic operation of the motor.

We have already discussed overload protection.

The Branch Circuit Protection

The motor branch circuit can be protected by fuses or a circuit breaker. Although it is to protect the branch circuit wiring and equipment, it must also have capacity to allow the motor to start.

Normally, a regular fuse or a circuit breaker element must be 250 to 300% of the motor full load amperage to start the motor. However, if delayed action fuses are used, then the size need be only as large as that to protect the motor.

If more than one motor is on a circuit, only the largest motor is figured at the higher percentage; the others are added in at 100% of rating.

The Motor Disconnect Switch

The disconnecting means is a switch for stationary motors, or can be a plug and receptacle for portable motors.

The disconnect switch must be rated in horsepower to correspond with the motor amperage (type C or A switches). An exception to this is that, for motors 2 horsepower and under, a general use switch rated in amperes only may be used if it has an amperage rating at least double that of the motor. When delayed action fuses are used, the horsepower rated switch has a "special" rating that may reduce the size of box needed.

The disconnect switch must be in sight of the motor (50 feet distance is considered to be out of sight) or be of a type that can be locked in the open or "off" position. The latter is an important point, for it may save the purchase of an additional switch. (See figure 16.) The branch circuit protection and the fused disconnecting switch can always be combined if a lock open type is used. And, in some cases, the control and overload protection can be incorporated in this same unit.

A thermal switch may, of course, be used in place of a fused switch, but it must have fuses (the branch circuit fuses could serve) ahead of it to protect the thermal elements.

A circuit breaker can be used for the disconnect, also. They are not horsepower rated. Minimum size is 115% of motor amperage rating.

The Motor Controller

The motor control must also be horsepower rated like the disconnect switch with the same exception for motors 2 horsepower and under.

The controller almost always incorporates the overload protection. An exception is the motor with built-in protection — refrigeration equipment is a common example (figures 3 and 7).

Controllers fall into three categories:

1. Manually operated fused switches—like the fused disconnect with which it may be combined.
2. Manually operated thermal switches—these merely substitute the bimetal element that may be "reset" rather than "replaced" for the fuse.
3. Magnetic switches. These must be used for automatic or remote control for the larg-

er motors (above approximately 1 horsepower), and also in many cases where a manual type switch is not available.

The manually operated fused switch is the cheapest installation where it can be used. (It cannot be used for equipment that is automatically controlled–i.e., by a thermostat, pressure switch or time clock.) The motor must be turned on and off by hand at this switch location. It could be used for hay driers and gutter cleaners, for example.

There are situations where this type of control cannot be obtained with the proper size fuse holders to hold the delayed action motor protection fuses for certain motors. If it is to be used, fuse clip reducers would have to be installed to accommodate the smaller delayed action fuses used for motor protection, and these are undesirable. An example is a 5 horsepower motor with full load current of 22 amperes. The correct size delayed action fuse is 25 amperes. The physical size of fuses changes at 30 amperes, 0–30 amperes being one size, and 35–60 amperes also one size but larger than the first. The 5 horsepower box would have at least 60 ampere holders. To use 25 ampere fuses would require a fuse holder reducer. (See "Special" Rating under Motor Disconnect Switch.)

However, if this motor drew 28 amperes, then a 35 ampere delayed action fuse for protection would fit in the regular fuse holder.

The manually operated thermal switch is commonly available up to a 5 horsepower size and some manufacturers make a 7½ horsepower size. Thus, this is a more desirable choice than the above fused disconnect with a fuse holder reducer. The 1 horsepower size is available for 115 and 230 volts. These switches serve the same purpose as the fused disconnect and control switches, except that they cannot be used for branch circuit protection since they must have fuse protection for the thermal element in case of heavy overloads or a short circuit. They have the additional feature of "resetting" the tripper instead of "replacing" a fuse. This makes them somewhat more costly, but perhaps more convenient.

The magnetic switch can be used for the control and overload protection of a motor. It cannot be used for branch circuit protection or for the disconnect. It must have fuse protection to protect the thermal elements from heavy overloads and short circuits, and a disconnect switch to isolate it from the power source.

Magnetic switches are used to control motors in the following situations:

1. Where it is necessary to start and stop a motor by means of a thermostat, pressure switch, float switch, time switch, or some other

automatic device that is too small to carry the full-load current of the motor. In this case, the automatic device controls current to the magnetic coil. (For most farm water pumps, the motor is small enough so the pressure switch can carry the motor current.)

2. Where it is necessary to have automatic control as described in paragraph 1 and also hand-operated control. This might be an automatic pump that can be operated continuously for fire protection, or a grain drying fan that might run continuously or on time-switch control (figure 13). In this case the magnetic switch is equipped with a selector switch or "Hand-off-Automatic" switch. This selector switch may be mounted in the cover of the magnetic switch or may be in another location. When the selector is turned to the word *Hand,* the motor runs under hand control. When it is turned to *Automatic,* the motor runs whenever the automatic device (thermostat, pressure switch, time switch, or the like) turns on. When it is turned to the *Off* position, the current to the magnet is cut off entirely.

3. Where it is necessary to prevent a motor from re-starting after the power is off. This might include a wood saw, ensilage cutter, or feed grinder where harm might come to the operator if the motor were to start suddenly when the power comes back on. In this case, the magnetic switch is equipped with a "Start-Stop" push-button control (figure 15). This push button is connected to the magnet coil in such a way that if the power supply fails even for an instant, the current to the magnet is cut off and the motor cannot be started again unless the "Start" button is pressed.

4. Where it is necessary to start and stop a motor from several locations. This is similar to the arrangement described in paragraph 3 but requires the installation of a "Start-Stop" push button at each location where it is desired to start and stop the motor (figures 15 and 16). If it is desired merely to stop the motor from another location, then a "Stop" push button is installed at that point. Any number of "Start-

FIGURE 13. MAGNETIC SWITCH AND THERMAL OVERLOAD PROTECTION FOR 5 HORSEPOWER MOTOR

Note the selector switch in the center for "Hand" or "Automatic" operation and "Off". Arrow points to "Reset" button near the "Heater" element.

Stop" or "Stop" push buttons can be installed to control a single motor.

An example of this arrangement might be a milking-machine motor that could be started and stopped in the dairy stable and also in the milk house if a vacuum line were run to the milk house for use in cleaning the milker units. Another example might be to control a conveyor elevator from two or more floors of a poultry house.

Sizes of Magnetic Switches

Magnetic motor-control switches are made in a wide variety of sizes. For farm motors, the size 0 is made for motors up to and including 1 horsepower at 115 volts and 1½ horsepower at 230 volts. Size 1 is for motors of 2 and 3 horsepower, 230 volts. For 5 horsepower, 230 volts, the control is sometimes known as *size 1½* or *size 1P*. For 7½ horsepower, size 2 is used.

These controls can be had with the "Hand-Off-Automatic" selector

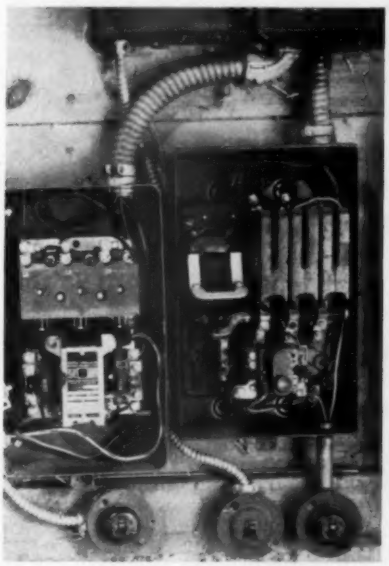

FIGURE 14. HAY-DRYER FAN CONTROL SWITCHES, WITH TOGGLE SWITCH CONTROLS TO MAGNETIC COILS SO FANS WILL START AUTOMATICALLY AFTER POWER INTERRUPTIONS

A selector switch is not included here

FIGURE 15. MAGNETIC CONTROL WITH SEPARATE "START–STOP" PUSH BUTTON CONTROL

The push-button control may be in the switch cover or in any desired location, also any desired number may be used

switch or the "Start-Stop" push button in the cover, or with a reset button only in the cover when the control is mounted separately.

The heaters (page 11) for the thermal cut-out protective device are, of course, determined from the motor full-load running current. Most thermal-type controls have a table of heater sizes for various motor currents pasted to the inside of the switch cover.

Grounding

Motors and equipment that are to be used or operated near grounds (the earth, water pipes, concrete floors laid on the earth, especially wet ones, or almost any wet or damp area) should have a separate equipment grounding wire connecting them to a ground. This wire is in addition to the circuit wires (the grounded neutral is one of the cir-

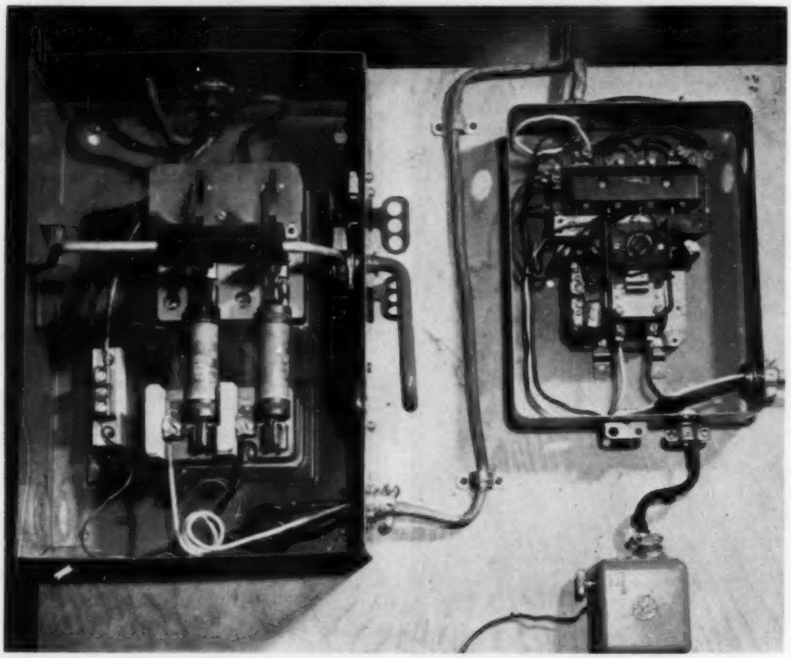

FIGURE 16. DISCONNECT SWITCH AND MAGNETIC MOTOR STARTER FOR LARGE MOTORS

Disconnect switch can be locked open. Motor is controlled automatically by a thermostat switch (lower right) connected to the magnetic or "Holding" circuit of the controller. Note the ground wire carried through for grounding the motor.

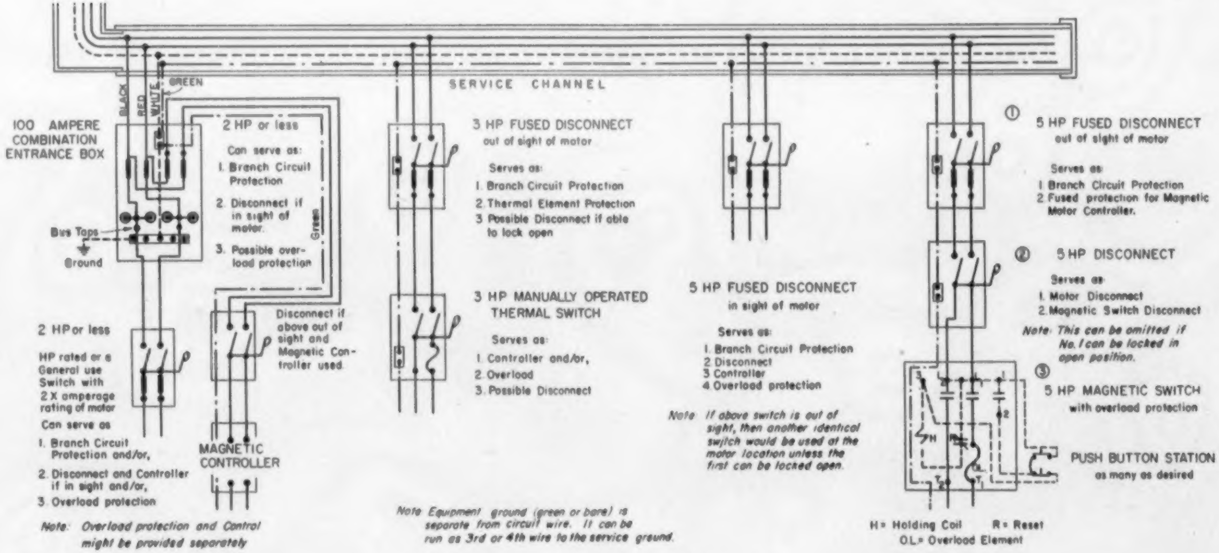

FIGURE 17. MOTOR CIRCUITS, 230 VOLT

Left. A combination entrance box with fuse pull-out blocks can serve motors of 2 horsepower or less. The two circuits show possible ways that the motors might be served and controlled. *Right.* Two 5 horsepower (or any size) circuits. The one with only the 5 horsepower disconnect is the simplest and cheapest means of control where it will serve the purpose. A magnetic switch is needed for all remote or automatic control. For automatic control, the sensing element switch is connected in the magnetic circuit instead of the push button momentary contact. Note: The extending, unconnected leads connect to the motor.

FIGURE 18. GROUNDING OF PORTABLE EQUIPMENT

Receptables have "U" slot to receive "U" prong on plug cap. Note octagon grounding terminal in receptacle and plug—painted green. Center receptacle is plastic surface type. (Wires disconnected in plug cap for clarity.)

cuit wires and is intended to carry current in the circuit). The equipment grounding wire is for safety to persons using or working around the motors in case of accidental grounds in the motor–i.e., a current carrying circuit wire coming in contact with the motor frame.

For stationary motors this wire is simply run along with the circuit wires (2 or 3 wire cable with ground wire) and connected to the motor frame at the one end and to the grounding conductor at the service (figures 16 and 17).

Portable motors that need grounding (an electric drill is a good example) should be equipped with a 3 prong plug cap, the third, a "U" type prong, being the grounding prong. This is of course connected to a grounding conductor in the cord which in turn connects to the motor frame. The convenience outlet must also have the grounding connection with the "U" type receptacle to receive this plug (figure 18).

When large portable motors need to be grounded, the standard range receptacle and plug (crowfoot prong arrangement) is most commonly available and used.

Caution

When the installation of an overload protective device entails a change in the permanent wiring, it is recommended that the new wiring be inspected by the local electrical inspector.

The farm service representative of the local electric company will be glad to help one select protective equipment for motors. The extension agricultural engineer can also help with this problem. He can be reached through the county agricultural agent.

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